*Proceedings — Fire Effects on Rare and Endangered Species and Habitats Conference, Nov. 13-16, 1995. Coeur d' Alene, Idaho.*




# *Pinus Pungens* Lam. (Table Mountain Pine): A Threatened Species Without Fire?

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**Abstract.** Southern Appalachian yellow pine communities were prehistorically and historically maintained by frequent fires of anthropogenic origin. Pre-Columbian Indian and European settler use of fire produced a diverse mosaic of grasslands, woodlands, and forests across the southern Appalachian landscape. Within forests, frequent burning prepared regeneration niches for shade intolerant yellow pine species and prevented competitive exclusion by hardwoods. However, federal land acquisition in the early 1900's essentially eliminated fire as a vector for maintaining a wide array of cover types. This allowed for succession toward hardwood dominated stands and the subsequent loss of yellow pine habitat. Most notable is the reduction in *Pinus pungens* Lam. (table mountain pine) communities. Fourteen 0.02-ha study plots were established in the Chattahoochee National Forest, Clayton, GA, in a classic *P. pungens, Kalmia latifolia*, and *Galax aphylla* community. Sampling of all stems ≥2.5 cm dbh revealed that mean basal area and density of combined hardwood species (19.76 $m^2$/ha and 930 stems/ha, respectively) were significantly greater than those of *P. pungens* (10.15 $m^2$/ha and 255 stems/ha) ($P<0.01$ and ($P<0.0001$). The importance value (relative basal area plus relative density) for *P. pungens* was 55.3 followed by *Quercus prinus* (52.4) and *Q. coccinea* (24.2). There was no evidence of *P. pungens* regeneration. These data suggest that P. pungens is being replaced by *Quercus* species in this area. Furthermore, analysis of the surrounding landscape structure revealed that conversion of pine to hardwood stands is occurring across the landscape. Pine-hardwood habitats occupied the greatest proportion of the landscape (65.5%) and had the largest average patch size (901.18 ha). These data suggest that previous pine habitat is succeeding to hardwood habitat. Reintroducing prescribed burning into such habitat is necessary to maintain *P. pungens* as a component of the southern Appalachian landscape and to maintain landscape heterogeneity.

## Introduction

### *Southern Appalachian Fire History*

Fire played an important role in shaping the species rich landscape of the southern Appalachian Mountains. Pre-historic lightning fires and use of fire by pre-Columbian Indians and colonial settlers contributed to the heterogeneity of forest types in the southern Appalachian landscape. Lightning caused fires were an environmental force in shaping the vegetation of the Southeastern United States for thousands of years before Indians arrived in America (Van Lear and Waldrop 1989). Montane forests of the southern Appalachians, however, probably did not burn as frequently as the pine-grasslands of the adjacent Piedmont (Van Lear and Waldrop 1989). Although considerable lightning is present in these mountainous areas, the opportunity for catastrophic fires is small. The mesic broad-leaved forest that dominates as a consequence of regular rainfall distribution and high humidity is not conducive to large widespread fires of natural origin (Komarek 1974). Therefore, prior to Indian settlement, the fire mosaic of this region was possibly a pattern of small burns interspersed over the landscape at irregular intervals (Komarek 1974) with occassional large fires.

Archeological records show that humans have occupied the southern Appalachians for over 12,000 years (DeVivo 1991). Resulting fires of anthropogenic origin have accounted for much of the Southeast's forest composition, which is dominated by disturbance-initiated species (Buckner 1989a). The first human inhabitants of eastern North America, the paleo-Indians, were largely hunters and gatherers who used fire in hunting large megafauna (Buckner 1989b). Of the pre-Columbian Indian tribes, Cherokee Indians were the largest population and occupied the greatest proportion of the southern Appalachian region. Their use of fire altered the pre-Columbian landscape and, as Buckner (1989b) described, produced "a shifting mosaic of open grasslands, woodlands, and closed forests with widely scattered Indian villages."

European settlers adopted some of the fire practices of the Indians as well as introducing their own burning techniques (Pyne 1982). As European populations increased, rich bottomlands along major streams quickly were settled and farming and logging practices (and associated burning) moved up-slope into the southern Appalachian Mountains (Van Lear and Waldrop 1989). The southeastern landscape thus became a mixture of European and Indian fire practices, one for farming and the other for hunting and ranging, respectively (Pyne 1982). European settlement, however, introduced small pox and other diseases which greatly reduced Indian populations and resulted in a marked decrease in fire frequency (Van Lear and Waldrop 1989). Subsequent effective fire suppression practices on both public (National Forest and National Park) and private lands lead to aggressive invasion of hardwoods on pine sites and, consequently, reductions in pine and pine-hardwood communities across the landscape (Buckner 1989b).

*Fire Suppression and Pinus pungens*

*Pinus pungens* is a shade intolerant, Appalachian endemic that occurs on thin soiled, southern and western slopes from central Pennsylvania to northeastern Georgia at elevations of 300 - 1220 m (Zobel 1969). *Pinus pungens* is one of four yellow pines native to the southern Appalachian Mountains [the others being Virginia pine (*P. virginiana* Mill.), shortleaf pine (*P. echinata* Mill.), and pitch pine (*Pinus rigida* Mill.)] (U.S.D.A. Forest Service 1965). These are all pioneer species that establish and regenerate stands following disturbance (U.S.D.A. Forest Service 1965). Specifically, the disturbance must create habitat of exposed mineral soil and full sunlight for successful yellow pine regeneration. *Pinus pungens* requires hot fires as the mode of disturbance to open their serotinous cones (Zobel 1969; Barden 1978; Sanders 1992).

The success of *P. pungens* regeneration depends upon the type and intensity of fire as well as the understory vegetation present in the stand. A post-fire study of the 1986 Bote Mountain, Tennessee, fire demonstrated that moderate to high intensity surface/crown fires are required to clear organic matter to expose mineral soil, open serotinous cones, and eliminate competition from hardwoods (Sanders 1992). Fires of such intensity were attained because *Galax* L. and mountain laurel (*Kalmia latifolia* L.) understories acted as fuel ladders. Indeed, *P. pungens* seedling densities were ten to fifteen times greater in medium and high intensity burn sites compared to low intensity burn sites. Estimated pre-burn density of mature *P. pungens* was 415 stems/ha with no pine regeneration present. Post-burn sampling showed a dramatic increase in *P. pungens* seedlings with densities of 12,256 stems/ha. The greatest proportion of these seedlings (96%) were located in high and moderate burn areas. Low intensity fires, however, were also beneficial as they killed back smaller competing hardwoods ocassionally creating large enough sites to allow *P. pungens* regeneration (Sanders 1992).

In the absence of disturbance, individual *P. pungens* trees may persist for up to 200 years (Zobel 1969). Although Barden (1977) reported self-maintaining populations of *P. pungens* on steep, xeric southwest slopes in North Carolina, regeneration is most often not successful in the absence of fire (Williams and Johnson 1990; 1992). *Pinus pungens* stands of the southern Appalachians have pine-hardwood codominants and understories that include *Quercus prinus* L. (chestnut oak)and *Q. coccinea* Mueschh. (scarlet oak), as well as other hardwoods (Zobel 1969; Barden 1977; Williams and Johnson 1992). Because *P. pungens* is very shade intolerant, it is usually replaced by more shade tolerant hardwoods in later seral stages in the absence of fire (Sanders 1992).

Pine to hardwood succession is the predominant stand dynamic occurring in the southern Appalachian region. Southern pine beetle *Dendroctonus frontalis* Zimm. epidemics speed this process. A 1992 survey of the Great Smoky Mountains National Park (TN and NC) identified over 63 *P. pungens* stands (defined as canopy composition ≥50% *P. pungens* over ≥2 ha). Of these stands, only eight had *P. pungens* seedlings. In addition, greater than 37% showed evidence of southern pine beetle activity (Konz, pers. comm.). Combined, southern pine beetle epidemics and effective fire suppression practices are altering structure and decreasing heterogeneity of the southern Appalachian landscape. The purpose of this study was to determine the canopy composition of a *P. pungens* stand in the Chattahoochee National Forest and to describe the structure of the surrounding landscape. The objective was to describe the extent of hardwood invasion that has occurred in this region.

## Materials and Methods

*Study Site*

This study was conducted in a classic *P. pungens*, *Kalmia latifolia*, and *Galax aphylla* community on the Chattahoochee National Forest (Tallulah Ranger District), Clayton, GA. Specifically, the sampled stand was located in the Warwoman Wildlife Management Area within the Chattooga Watershed. *Pinus pungens* communities are found between 1040 and 1100 m in elevation in this area.

Bratton and Meier (unpublished data) recently compiled a descriptive fire history of the Chattooga Watershed. Fire was pre-historically and historically frequent in this area. In May 1775, William Bartram described semi-open areas ("vales"), meadows and fields in the Chattooga Watershed region, implying the understories were relatively free of shrubs. This open colonial landscape was most likely due to frequent burning by the

Cherokee Indians or to a combination of burning, grazing, and farming.

The landscape remained relatively open through the late 1800's. In terms of fire, there was an increase in forest clearing in the first part of the 19th century with the activities intensifying around 1820. Written records verify major fires during the 19th century although ignition sources were not recorded. Slash fires associated with logging activities were prominent from the 1880's through the 1920's. Following the advent of the USDA Forest Service in the Chattooga Watershed region, the government began suppressing fires around 1913. After World War II (1950's-1970's), ignitions increased due to an abundance of arson fires and escaped campfires. Since 1980, however, the frequency of arson fires has decreased [Bratton and Meier (unpublished data)].

All reports and maps studied by Bratton and Meier (unpublished data) indicated that lightning ignited fires are relatively rare in the Chattooga Watershed. Indeed, Forest Service fire records showed only eight lightning ignited fires in the Rabun Bald area between 1950-1994. Those that do occur strike southern, southwestern, and western ridges typically between 610-760 m elevation. Most lightning ignited fires remain one acre of less due to suppression efforts and humid nature of southeastern thunderstorm activity.

*Sampling*

*Canopy Composition*

Fourteen 0.02 ha (10 x 20 m) plots were established in the Rabun Bald area of the Chattahoochee National Forest. All woody stems ≥ 2.5 cm dbh were noted as to species and measured for diameter breast height (dbh). An approximate number of cones was recorded for each coniferous tree. Height of shrub species was estimated in the upper and lower quarters of the plot. Litter and organic matter depths were also noted in these areas. Cover was visually estimated for herbaceous species (all vascular plants ≤ 1 m in height) within four 1 $m^2$ subplots. Importance values of canopy species were calculated as relative basal area plus relative density. Means were compared using PROC TTEST in SAS (SAS Institute 1989).

*Landscape Structure*

An aerial photo of the region was digitized as to cover type (pine, pine-hardwood, and hardwood) using a 24x24 cell grid. Each grid cell represented 14.35 ha. Cell assignments were assessed by the cover type that occupied ≥ 50% of the cell. If no cover types dominated the cell to this degree, the one with the greatest area was specified.

A table of the digitized vales was created in Edlin Editor. Spatial Analysis Computer Program (SPAN) was used to analyze these data. SPAN is a grid cell based analysis program applicable to any categorical, rasterized data. Measures of spatial pattern calculated include (1) proportion of the landscape occupied by each category, (2) size of each patch), (3) fractal dimension of patch perimeters, (4) edges between each pair of land-cover types, (5) diversity index, (6) dominance index, and (7) contagion index (Turner 1990).

## Results

*Canopy Composition*

*P. pungens* was the most important canopy species followed decreasingly by *Quercus prinus* and *Q. coccinea* (Table 1). Mean basal area of hardwood species (mean ± 1 standard error) (19.76 + 2.55 $m^2$/ha) significantly exceeded that of *P. pungens* (10.15 ± 1.97 $m^2$/ha) ($P \leq 0.01$). Similarly, mean density of hardwood species (935.50 ± 73.50 stems/ha) was significantly greater than that of *P. pungens* (253.50 ± 51.50 stems/ha) ($P \leq 0.0001$). The majority of *P. pungens* stems were between 10-30 cm dbh whereas most *Q. prinus* and *Q. coccinea* stems were between 5-20 cm dbh (Figure 1). Only seven *P. pungens* stems were between 0-10 cm dbh class whereas 34 *Quercus* stems between 0-10 cm dbh were found (Figure 1). Mean number of estimated *P. pungens* cones was 4071.43±3723.97 cones/ha. *Kalmia latifolia* dominated the shrub layer. Mean shrub height was 2.79±0.55 m and mean shrub density was 3142.86±2093.20 stems/ha. *Vaccinium* sp. and *Galax aphylla* dominated the herb layer. Mean herb layer cover was 42.73±18.50 %/$m^2$. Mean depth of litter and organic matter were 4.23±1.53 cm and 11.07±3.45 cm, respectively.

**Table 1.** Canopy species of the Chattahoochee National Forest, Clayton, GA. Importance value (IV) calculated as relative basal area plus relative density.

| Species | Relative Basal Area | Relative Density | IV |
|---|---|---|---|
| *Pinus pungens* | 33.77 | 21.49 | 55.26 |
| *Quercus prinus* | 27.30 | 25.07 | 52.38 |
| *Q. coccinea* | 12.28 | 11.94 | 24.22 |
| *Nyssa sylvatica* | 4.99 | 11.64 | 16.64 |
| *Q. alba* | 6.31 | 7.76 | 14.07 |

*Landscape Structure*

Figure 2 is a coded chart that outlines patches recognized by SPAN. Pine-hardwood occupied the greatest total area of the region followed decreasingly by hardwood and pine (Figure 3). Indices of landscape diversity (0.87) and dominance (0.23) were low.

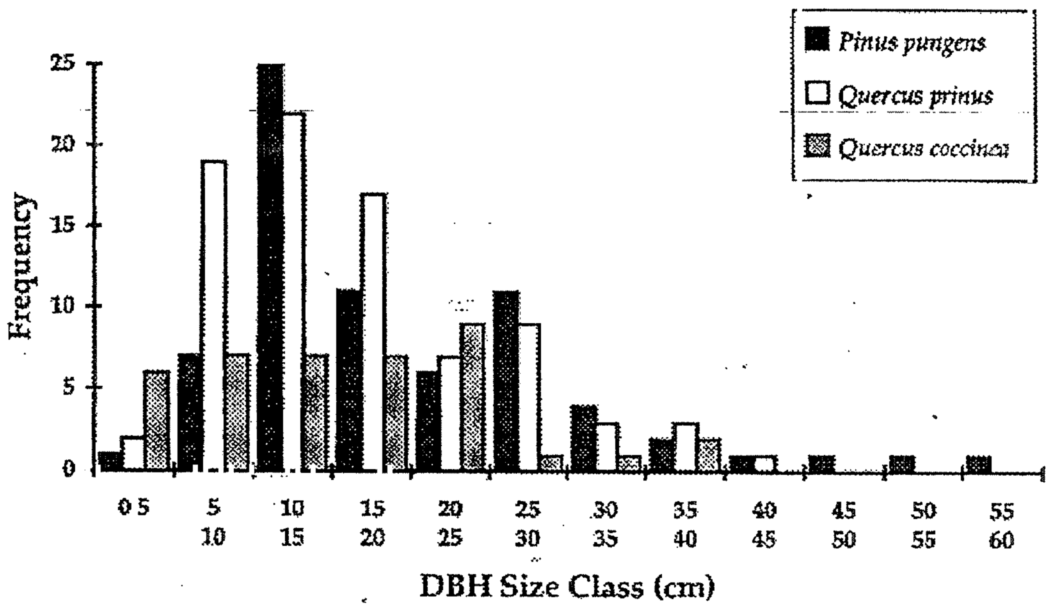


Figure 1. Size class distribution of canopy species in a *Pinus pungens* stand of the Chattahoochee National Forest (Clayton, GA).

Pine-hardwood (n=6) had the greatest average patch size and was followed decreasingly by hardwood (n=22) and pine (n=23) (Figure 4). The contagion index was low (0.33). High amounts of edge occurred between pine and pine-hardwood areas and pine-hardwood and hardwood areas. The range of fractal values was 1.00-1.57. Average fractal values were comparable among the cover types [hardwood (1.14), pine (1.15) and pine-hardwood (1.20)].

## Discussion

These data suggest that the sampled stand is converting to a hardwood stand. *Pinus pungens* and *Q. prinus* were canopy co-dominants. *Pinus pungens* had a slightly higher importance value and occupied nearly one-third of the basal area of this stand (Table 1). *Quercus prinus* followed closely in importance and occupied one-quarter

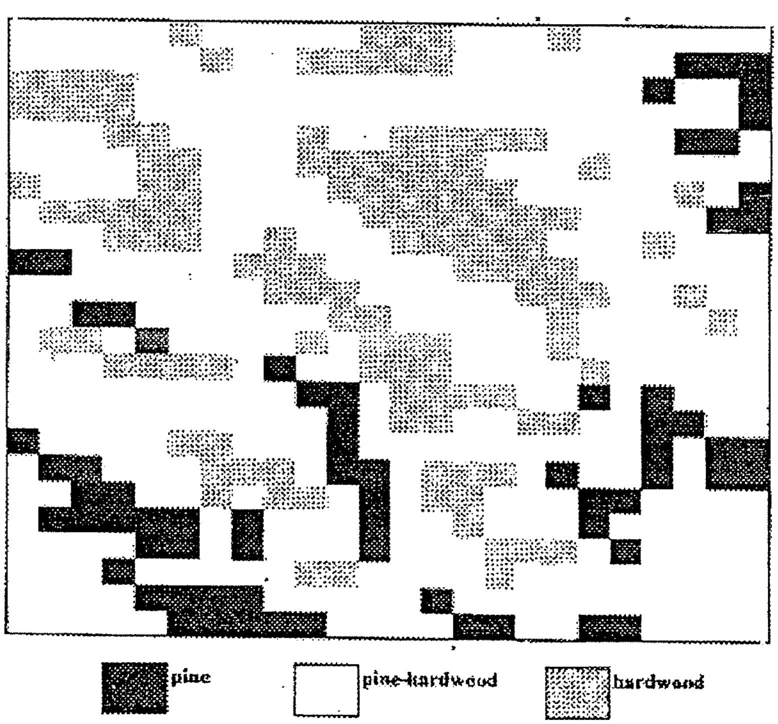


Figure 2. Map of landscape cover types surrounding a *Pinus pungens* stand in the Chattahoochee National Forest (Clayton, GA).

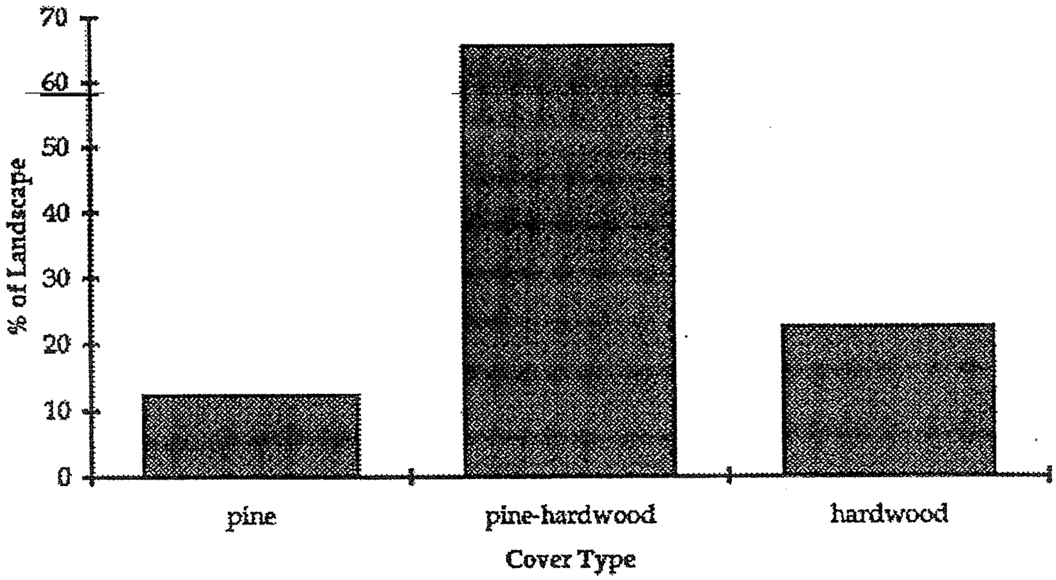


**Figure 3.** Cover type proportions of the landscape surrounding a *Pinus pungens* stand of the Chattahoochee national Forest (Clayton, GA).

of the stand density (Table 1). Mean basal area of all hardwood species combined was nearly double that of *P. pungens*. In addition, mean density of all hardwood species combined was three times greater than that of *P. pungens*.

The *P. pungens* component of this stand is not regenerating. The majority of *P. pungens* stems were observed in larger dbh size classes whereas most *Q. prinus* stems were found in smaller dbh size classes (Figure 1). Closed canopy (i.e., low light), thick litter and thick organic matter conditions have eliminated regeneration niches for *P. pungens*. However, the abundance of *Q. prinus* and *Q. coccinea* stems in the 0-10 cm dbh indicates that these species are able to regenerate in this setting. If fire continues to be excluded from this area, *Quercus* sp. eventually will dominate the stand.

Williams and Johnson (1990; 1992) noted a similar decline in recruitment and population maintenance of *P. pungens* in southwestern Virginia montane pine-oak forests. In the absence of fire, the number of stems per hect-

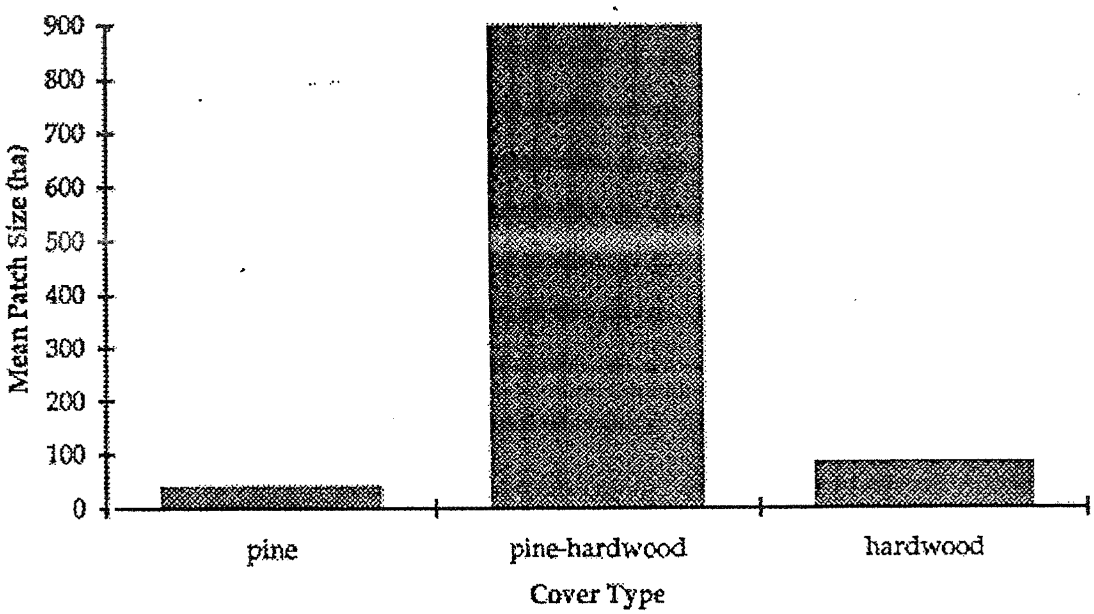


**Figure 4.** Comparison of cover type patch size for the landscape surrounding a *Pinus pungens* stand in the Chattahoochee National Forest (Clayton, GA).

are was greatly skewed toward larger diameter classes (15-35 cm dbh) for *P. pungens* indicating little regeneration of this species. On the other hand, *Quercus prinus* and ~~*Q. coccinea* were successfully regenerating in the under-~~story and were predicted to become canopy dominants under continued fire suppression practices (Williams and Johnson 1990).

Hardwood encroachment also is apparent on the landscape level. Pine communities are restricted to ridge tops (Figure 2). A general up-slope transition from hardwood to pine-hardwood to pine is seen across rolling terrain. Pine-hardwood occupies the greatest proportion of the landscape (Figure 3) indicating that previous pine habitat is succeeding to hardwood habitat. The low index of dominance suggests that no one cover type dominates the area. A low index of diversity reveals that the cover types are somewhat evenly distributed across the landscape.

Pine-hardwood patches are larger than pine or hardwood patches (Figure 4) and are more contiguous across the region. Low fractal dimensions reveal that most recognized patches, regardless of cover types, are of simple shape. Low fractal dimensions are typical of disturbed areas (O'Neill et al. 1988). Bratton and Meier (unpublished data) reported that disturbance was historically prevalent in this area.

*P. pungens* communities of the Chattahoochee National Forest are currently under great stress from hardwood encroachment on both regional and local scales. It is now evident that continuation of passive (protective) management will result in further hardwood dominance and a decrease in landscape heterogeneity. Restoring fire to these areas would prevent this from occurring. The structure of this *P. pungens* community would support an intense fire. The tall *K. latifolia* would act as fuel ladders to carry the heat up to the serotinous cones. The abundance of *G. aphylla* and *Vaccinium* sp. in the herb layer would promote a hot surface fire that, if under dry conditions, would remove the deep build up of litter and organic matter. Fire also would eliminate much hardwood competition. Establishing guidelines for a pro-active program that will identify the steps needed to regenerate decadent *P. pungens* stands is essential to their survival.

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